Some people are best trained in this manner, but other persons with a vivid practical interest or experience in application to life and work are best trained in close touch with practical conditions. Medical training is the best example; that is thoroughly done. We would have other training arranged on the same practical lines. The modern university will seek, so far as it can, to allow for differences of aptitude, or, it may be, differences of preliminary training. It will not seek to force every undergraduate at first through an arts course, and then through a science course, and then through a technical course. It may be well to do this with professional men, but not with all. Every graduate should pass through these three stages before he can be turned out a useful and educated citizen, fit intellectually to take his share in the work of the world; but he need not in every case of necessity take them in this logical order.

To force a boy through a course of language or history or literature, at a period when for some reason he is not attracted by it, is doing him but little good. It may, indeed, do him harm, by breeding disgust for subjects which at a later stage he might realise were necessary, and, when properly taught, enthralling. It is love of culture, and not hatred of it, that should be implanted. The so-called "preliminary in arts" course should be taken compulsorily at some stage of a graduate's complete career, but not necessarily at the beginning A student who has been immersed for a term in purely technical studies will, if he is good for anything, turn to such human subjects with relief; and it is not fair to turn him out in the world without some worthy human interest and solace. The university has failed in one of its functions if it permits him to depart trained in nothing but unhuman technology.

But then, on the other hand, the arts man, the lawyer, the merchant, the man of business, and still more the teacher—how much better would they not be for a tinge of scientific training. Their ignorance does not come home to all of them, but to many it does; and probably in middle life they strive, by attending popular lectures and miscellaneous semi-scientific entertainments, to obtain a growth by a top-dressing of superficial information never really assimilated, seldom adequately understood. A manuring of science placed low down when young would have rendered the surface soil fertile, and this later growth easy, just as the youthful smattering of letters renders moderately easy and interesting the subsequent reading of history, or, in some cases, even the learning of a new language; but to the wholly untrained person these things are, and remain, hopelessly difficult.

A broad training all round can only result in what specialists would call a smattering—what we should prefer to call a leaven; but so long as it is not confined to a learning of trivial details, but represents a grasp of some of the fundamental principles of a subject, it is all that most men ever have, or can have, in any branch but their own, however highly educated they may be. It takes a very exceptional man to be really learned, or to be able to say anything really worth hearing, off his own subject. There are men who make a large portion of knowledge their province, but the majority of men cannot and should not aim at this. They should know one thing well, and in all else they should not be entirely ignorant.

This absence of entire ignorance is a far more valuable commodity than is usually supposed. It enables the man of affairs to consult specialists with advantage. Special knowledge is always available, if one knows how and where to look for it; but the man of complete ignorance is at the mercy of every charlatan; he puts his money into the wildest scheme, on the one hand, and on the other he fails to realise possibilities of sound application lying all about him. His enterprise and power may be great, but the blight of ignorance makes him useless; and it is just this blight which is endangering our continued industrial and commercial supremacy among the nations of the world.

We look to the new type of university now about to be created to remedy this state of things. If Birmingham succeeds in its high emprise, other great cities will follow suit. The experiment is one that is of interest to the whole British Empire, indeed to the whole Anglo-Saxon race.

In another article we may perhaps enter more into detail concerning some of the features of the scheme; but it is at present in such extreme infancy that its features are barely recognisable. It does not follow that what is immediately to the front is in reality the most important or the most characteristic.

(*To be continued.*)

THE STEADYING OF SHIPS.[1]

THE evolution of the modern flat-bottomed merchant vessel, with its midship section of approximately rectangular form, from its old pointed-bottomed prototype, with deep central keel, has been a necessary result of commercial competition. The naval architect is called on to increase the carrying capacity of his vessels to the utmost extent, and a limitation is imposed on their draught of water by the limited depth of harbours, docks, rivers and, last but not least, ship canals. The old central keel has had to disappear in order that the extra foot or two of displacement might be utilised for the carriage of cargo, and a substitute has had to be found for it by the attachment of "bilge-keels" or side keels projecting from the ship at the only places where they could be placed without taking up valuable space—namely, at the two rounded-off corners of the rectangular section.

The efficiency of bilge-keels in modifying the rolling oscillation of ships seems to have been for some time a debated point among naval architects, and the experimental fact that the extinction of oscillation produced by these keels may in some instances be many times—possibly as much as ten times—that which would be inferred from determinations of the resistance of a paddle oscillating in water certainly appears at a first glance paradoxical. On reading Mr. Luke's paper in the *Transactions* of the Scotch Shipbuilders, and subsequently Sir William White's account of his experiments on the *Revenge*, it occurred to me that the properties of discontinuous fluid motion, so long a favourite study among mathematicians, might be put to a useful purpose in explaining the high resistances to rolling observed with the use of bilge-keels. So far from these resistances being in contradiction with the principles of hydrodynamics, they appeared to be to a large extent in conformity with our theory of free stream-lines, and this view has been borne out by subsequent calculations, certainly to a far greater degree than I at first anticipated.

According to hydrodynamical theory, if a solid body is set moving through or rotating in an unlimited mass of perfect fluid previously at rest, the motion will continue indefinitely, provided that the body has no sharp edges or corners projecting into the fluid, and that the velocity does not exceed certain limits. The motion involves no continuous expenditure of energy, and if the solid is brought to rest, the fluid will come to rest, and the energy which was expended in starting the motion will be recovered. If, however, the body has any sharp projecting edges, the fluid is unable to flow continuously round these, and discontinuous motion is set up, a mass of dead water being dragged along behind the projecting edges, and this dead water being separated from the moving fluid by a "surface of discontinuity" in crossing which the velocity changes abruptly. In this case the fluid motion is not destroyed when the solid is brought to rest, and energy is absorbed by the fluid. The theory of discontinuous motion is the basis of the well-known calculations of the resistance experienced by a plane lamina moving through a liquid, originally due to Kirchhoff, and subsequently developed by Lord Rayleigh, Love, Michell and others.

The case of a ship floating in water rocking from side to side differs from these ideal cases in the properties (1) that waves are produced on the surface, (2) that water is not a *perfect* fluid; so that energy is being continuously absorbed by wave-formation, and by the viscosity of the water. If the ship has no sharp keels projecting into the water, these are the only causes which retard the rolling of the ship, but as soon as keels are attached discontinuous motions are set up, which involve a further absorption of the energy of rolling, and the oscillations subside much more rapidly. If we imagine the ideal case of a ship floating in a perfect liquid, the surface of which is coated with a perfectly rigid sheet of ice entirely preventing any waves from forming, but just allowing free play for the ship to roll, the oscillation would continue indefinitely, provided the ship had no sharp projecting keels. If, however, bilge-keels were attached, the oscillations would gradually die down, the energy of rolling being absorbed by the production of discontinuous motions, and being transformed into kinetic energy of the liquid.

The object of this investigation is to show that the efficiency of bilge-keels in modifying the rolling of ships may be greatly increased by the action of the sides of the ship itself, and is so increased in a ship of section approaching to a rectangular form, provided that the bilge-keels are attached at the protruding

[1] Abstract of a paper read before the Institution of Naval Architects.

corners of the section. This increased efficiency is due to two causes:—

(1) The rocking of the ship produces currents in the water, which flow round the corners in the opposite direction to that in which the ship is rolling, thereby increasing the pressure on the bilge-keels.

(2) The discontinuous motion past the bilge-keels alters the distribution of pressure against the sides of the ship, and the differences of pressure thus produced have a moment always tending to retard the rolling motion.

The effect of stream-line motions.—Consider a cylinder of section, such as represented in Fig. 1, rotating in fluid about

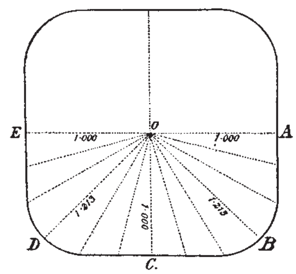

FIG. 1.

an axis through its centre O. It is known that the fluid displaced by the motion of the cylinder will flow past its protruding corners B, D in the opposite directions to that in which the cylinder is moving; while at the points A, C, E the fluid will be moving in the same direction as the cylinder. Hence if a small lamina representing a bilge-keel be placed at B or D, it will encounter a current of liquid flowing in the opposite direction to that in which it is moving, and the pressure on the lamina will be correspondingly increased.

I made several calculations to form some estimate of the increases produced by these counter-currents on the resistance experienced by a suitably placed bilge-keel, assuming the resistance to vary as the square of the relative velocity. Taking certain sections more or less approximating to the form of a square with rounded corners, in a section where the greatest radius O B exceeded the least radius O A by 13 per cent., the resistance was increased, owing to this cause, by about 36 per cent.; while in the section actually represented in Fig. 1, O B exceeded O A by 21 per cent., and the resistance on a lamina at B came out 67 per cent. greater than it would be if the lamina had only to encounter the relative velocity of the fluid due to its own motion.

In these cases the fluid was supposed to be indefinitely extended. To estimate the influence of surface-conditions *without*

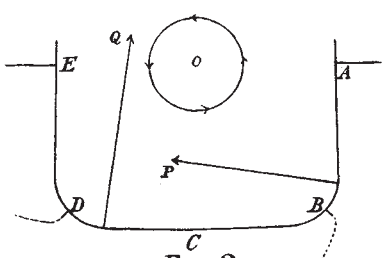

FIG. 2.

taking account of waves, I next considered the case of a cylinder partially immersed in a liquid bounded by a rigid horizontal plane, the cylinder itself rocking about an axis in the plane of the surface. The form chosen for the section of the submerged portion was roughly suggested by a diagram of the ship *Revenge*, and the counter-currents past the protruding corners were found to be sufficient to more than double the resistance on a suitably placed bilge-keel.

The effect of pressure-variations against the sides of the ship.—The resistance on a lamina moving in fluid is due to the pressure being greater on the front than on the back of the lamina, this difference of pressure being the result of the discontinuous character of the fluid motion. When the lamina is attached to a ship as a bilge-keel, this difference of pressure also extends along the sides of the ship, the pressure in front of the bilge-keel being greater than behind it. Whether the pressure in front is increased or the pressure behind is decreased, or both of these effects take place simultaneously, is unimportant, for we may on each of these hypotheses represent the effect by an excess of pressure on the portions in front of the bilge-keels as compared with the portions behind.

Now let Fig. 2 represent a diagrammatic section of a ship approaching to a rectangular section, with bilge-keels at its protruding corners, B, D. Then if the ship be rolling about its centre of gravity, O, in the direction of the circular arrow, the greater pressures in front of the bilge-keels will be distributed over the segments A B and C D, and, as indicated by the arrows P and Q, their moments about O will be in the direction opposed to rotation. When the ship rolls in the opposite direction, the greater pressures will be on the segments B C and D E, and their moments will again tend to retard the rolling. In this way the pressures on the sides of the ship will materially assist the bilge-keels in steadying the ship.

To test the extent to which the pressure on the sides of the ship is likely to be modified by the presence of the bilge-keel, I examined the case of a fluid flowing along a plane, A B, with an edge, B C, projecting at right angles to it (Fig. 3). If from B there be measured off on B A a length = ·927 B C approximately, the thrust on this portion of B A is equal to the thrust on B C, and the average pressure on this portion is therefore a little greater than the average pressure on B C. If, again, we measure off on B A a length = 2·042 B C, the thrust on this portion is equal to twice that on B C. Speaking in general terms, we may say that the

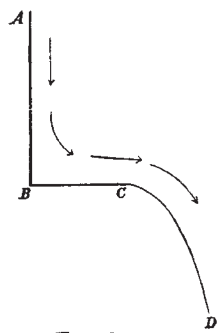

FIG. 3.

pressure is greater along B A than along B C, and that it does not fall off rapidly along the arm B A. If the arm B A, instead of being straight, bends away from B C like the curved side of a ship, we should expect the pressure on it to be even greater than in the case considered. These considerations led me to consider the results of supposing the bilge-keels to produce on the segments in front of them (A B and C D of Fig. 2) uniform increases of pressure equal in intensity to the average pressures on the keels themselves. Applying this hypothesis to a ship, the details of which were kindly furnished me by Dr. Elgar, I found that the total retarding moment came out to be about 3·9 times the retarding moment on the bilge-keels alone. This result, taken in conjunction with the previous result that the currents past the sides of the ship may double the pressure on the bilge-keel, shows that there is nothing paradoxical in the supposition that bilge-keels may have eight times the efficiency in extinguishing oscillations that would be inferred from experiments made with a simple paddle moving freely in fluid.

We learn from Sir William White that in the case of the *Sultan* the agreement between Mr. Froude's estimate of the resistance to rolling, based on the coefficient of resistance of a lamina, and the experimental facts was very close indeed. But the midship section of the *Sultan* was very much more nearly circular than that of the other ships experimented on. For a circular section there would be no counter-currents producing increased resistance, nor would the changes of pressure against the sides of the ship possess any retarding moment.

There are many further points connected with the investigation which want of space prevents us from discussing here. One such point is the fact that the rolling motion is not steady, but oscillatory, and, therefore, account must be taken of the pressures involved in producing changes of motion, in consequence of which the pressures differ from those which would exist at any instant if the motion were steady. These pressures, which I have called the "$d\phi/dt$ pressures," after the term which produces them in the hydrodynamical equation, are completely modified in their action when continuous motion is replaced by discontinuous motion, but their effect can only be discussed from general principles. Other points are the effect of the ship's forward motion in increasing the steadying action, and the influence of bilge-keels in modifying pitching and in improving the steering of ships; the two last effects are further simple consequences of the properties of discontinuous motion.

We have seen that the action of bilge-keels in steadying a ship is largely modified by the actions of the sides of the ship, and is much augmented when the keels are placed in a suitable position; and it is interesting to notice how the exigencies of trade, while they have necessitated the removal of keels from the middle line of the ship to the sides, have brought about such a change in the form of the section as to render the new position by far the most effective. In the old pointed-bottomed ship, the central keel was the best, as it not only intercepted the currents flowing round the bottom in each swing from side to side, but also produced a difference of pressure on the two sides whose moment was always opposed to rolling. In the modern flat-bottomed ship of rectangular section a central keel would be unfavourably placed for this purpose, as not only would the water tend to flow in the same direction as that in which the ship is rolling, producing a diminished pressure on the keel, but the differences of pressure on the sides of the ships would have a moment tending to diminish the resistance to rolling. The favourable position now commonly assigned to the bilge-keel is calculated to render its addition to ships of the greatest value in increasing their steadiness. G. H. BRYAN.

THE "ORTHOSTIGMAT" LENS.

A SPECIMEN of the new series of lenses issued under the joint auspices of Messrs. Beck and Steinheil, has been tested and examined by us. The lens is of the rectilinear symmetrical type with two equal combinations, each consisting of three elements. It is by special construction of the surfaces of these components that the remarkable qualities claimed for, and undoubtedly possessed by, the new lens are attained. The great drawback to the best of the old type lenses was the curvature of field, and it is only in recent years that the discovery of the new varieties of glass has made it possible to correct this, and at the same time perfect the corrections for spherical aberration and astigmatism. The result of the process is that each component of the lens is made up of a positive meniscus, with a double convex lens cemented on one side of it and a double concave one on the other. The centre positive lens will consequently have a lower power than the two outer ones.

When it is understood that each of the twelve surfaces involved in the complete lens is worked with such accuracy that an error of 1/40,000th of an inch is inadmissible, the increased price, compared with the old types of lenses, is amply accounted for in the superior product obtained.

We have tested the lens, which is of about 4¾ inches solar focus, and are quite satisfied that it fulfils to a high degree of perfection the claims made for it by the makers. Although the lens is listed for ¼ plate, the circle of good definition is much larger, and with a stop of $f/16$ excellent definition was obtained over the whole of a ½ plate. The lens at its greatest rapidity works at $f/6{\cdot}3$, and at this aperture the definition appears very perfect over an area 4¼ inches square. The makers call attention to the special attempts they have made to eliminate astigmatism, and it is not until an oblique pencil falls considerably beyond the listed angle that any distortion shows itself. To make this clearer, let the image of the sun, moon, a star, or any distant object, be focussed at the centre of the plate, and then the camera so tilted that the image falls gradually away to the extreme corner. The slightest distortion can be at once recognised in this manner. With the lens in question no distortion was evident until the image was received at an angle of about 30 degrees from the axis, and for another 10 degrees further the resulting astigmatism, although present, was much less than is present closer to the axis in a rectilinear of the ordinary type. So that for an angle of view of over 60° the new lens is practically non-astigmatic at the large aperture $f/6{\cdot}3$ This will recommend it especially for all process and copying work, where critical definition and speed are primary necessities. A word should be said concerning the focussing with these new lenses. This adjustment must be critical, as an almost imperceptible displacement of the plate will suffice to throw it out of the focal plane sufficiently to destroy the definition, and so create false impressions of the capabilities of the optical system. For all such work, therefore, only perfectly rigid apparatus is permissible.

Another important qualification of the lens is its comparative freedom from chromatic aberration, in virtue of which it will be useful for work connected with colour photography, obviating the laborious and uncertain corrections which are necessary in such work with the ordinary lenses, whose chromatic aberrations are only suppressed for the blue and yellow. Critical tests of this correction have not been possible, but sufficient have been made to show that the outstanding error is small.

On account of their covering power, the smaller sizes will be found excellent for low-power microphotography. The new lenses are obtainable with foci varying from 3½ in. to 23½ in., covering plates from 3¼ in. square to 28 × 24 inches.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The Romanes Lecture will be delivered by Dr. James A. H. Murray on Friday, June 22, upon "The Evolution of English Lexicography."

Sir William Thiselton-Dyer, F.R.S., has been made a permanent elector to the Sherardian Professorship of Botany, in succession to the late Prof. Bartholomew Price.

The Statute instituting Diplomas in Geography has been approved by Convocation, and is to remain in force until October, 1904.

The extensive bequest to the University under Mr. Fortnum's will has made an enlargement of the Ashmolean Museum necessary. The cost is estimated at 1500*l*., and towards this sum Brasenose College has offered a contribution of 500*l*.

At Merton College there will be an election to a fellowship on October 6, after an examination in Animal Physiology and Animal Morphology. Candidates are requested to inform the Warden by September 10 of their choice between these two subjects, and to submit, if they wish, original papers or memoirs.

At a meeting of the Oxford University Junior Scientific Club, held on Wednesday, June 6, Sir John Burdon Sanderson, F.R.S., gave an account of the method he has been lately employing for producing tetanus in muscle, by means of telephone currents produced by musical sounds, showing how the results bear on the vexed question of the inherent rhythmicality of muscle and nerve-cell. The lecture was illustrated by experiments.

At a meeting of the above club held on Friday, June 15, Mr. T. C. Porter, of Eton College, described the growth of the shadow of the Peak of Teneriffe, as witnessed from the summit of the mountain at sunrise and sunset, and its gradual eclipse by the shadow of the earth. He showed photographs taken at the time, and explained how by means of an ordinary watch and pair of opera glasses a rough value of the diameter of the earth might be deduced.

Mr. A. F. Walden, New College, made a preliminary communication to the club on the theory of labile hydrogen atoms.

CAMBRIDGE.—The researches of Mr. J. C. McLennan on electrical conductivity in gases traversed by kathode rays, and of Mr. R. L. Wills, of St. John's College, on the magnetic properties of iron as influenced by temperature and the presence of other elements, have been approved by the Degree Committee as qualifying for the B.A. degree.

In the Natural Sciences Tripos, which is now the largest of the Honour Examinations, forty men and three women are placed in the first class of Part I. In Part II. fourteen men and no women obtain first-class honours.

At St. John's College the following awards in natural science were made on June 18. Foundation Scholars continued or elected: Lewton-Brain, May, Adams, Ticehurst, Fletcher, Browning, Wakely, Gregory, Williams, Harding, Hepworth,